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Mortality From Stomach Cancer in Coal Mining Regions

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To evaluate reported correlations between stomach cancer and coal mining in Utah, we compared mortality for gastric cancer in 23 coal mining counties in seven states of the United States during 1950 to 1969 with other counties, matched by educational level. Observed deaths were 20% to 30% greater than expected for men and women ($P < .01$), but a similar excess was noted for other cancers related to low socioeconomic class (lung, cervix). Conversely, significantly fewer deaths than expected occurred for neoplasms related to high social class (leukemia, breast, and colon). Thus, it is suggested that the correlation is with socioeconomic class rather than with occupation.

Surveys from Utah (1965 to 1969) revealed in two counties a high rate of gastric cancer that seemed related to coal mining and extensive use of soft coal.[1,2] Other studies have reported excess mortality from this tumor among coal miners.[3-8] However, it is unclear if the findings are due to coal exposure or simply reflect the increased risk of gastric malignancy associated with lower socioeconomic class.[9] The present analysis compares mortality from stomach cancer and other neoplasms in coal mining areas of Utah and of six other states with that occurring among comparable non-coal mining regions for the period 1950 to 1969.

Methods

An operational computer system developed by the Epidemiology Branch of the National Cancer Institute provided the capability of analyzing cancer mortality for all counties of the United States from 1950 to 1969, by age, race, sex, and tumor site. The number of fatalities was obtained from the National Center for Health Statistics. Population estimates for counties were calculated by linear interpolation of census data for 1950, 1960, and 1970. From data provided by the Bureau of Mines,[10] we identified all counties in the United States in which underground bituminous coal miners comprised at least 25% of white men in the age group 25 to 59 years (Table 1). Stomach cancer mortality in the white population of these counties was compared with that in counties with no reported underground coal miners but which comprised similar social classes measured by median years of education completed by the male population over age 25.[11] The first county encountered in an alphabetical listing of counties in the same state which matched the coal mining county precisely by educational status was chosen as a control.

Illinois
- Coal county: Gallatin
- Controls: Calhoun, Hardin, Washington

Kentucky
- Coal counties: Floyd, Harlan, Knott, Leslie, Letcher, Perry, Pike
- Controls: Breckinridge, Cumberland, Elliott, Estill, Lewis, Powell, Todd

Ohio
- Coal county: Harrison
- Controls: Fayette, Highland, Madison

Pennsylvania
- Coal county: Greene
- Controls: Adams, Fulton, Juniata

Utah
- Coal counties: Carbon, Emery
- Controls: Duchesne, Wayne

Virginia
- Coal counties: Buchanan, Dickenson, Wise
- Controls: Amelia, Franklin, Greensville

West Virginia
- Coal counties: Boone, Grant, Logan, McDowell, Monongalia, Nicholas, Raleigh, Wyoming
- Controls: Calhoun, Hampshire, Hardy, Lincoln, Pendleton, Doddridge, Jefferson

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Table 1.—Populations of White Men and Underground Bituminous Coal Miners in Selected Areas: Their Educational Status Compared With Non-Coal Mining Areas

Location of Coal Mining Areas	White Men in Selected Coal Mining Areas			Median Years of Education* (Age >25 yr)		Percent of Rural Population*	
	Total (Age 25-59 yr)	Coal Miners		Coal Mining Counties	Non-Coal Mining Counties	Coal Mining Counties	Non-Coal Mining Counties
		No.	%				
Illinois	1,470	617	42.0	8.4	8.4	81.9	89.7
Kentucky	36,520	14,282	39.1	7.8	7.7	88.5	95.9
Ohio	3,195	2,142	67.0	8.9	9.0	81.9	59.9
Pennsylvania	6,436	3,487	54.2	8.6	8.8	86.8	82.7
Utah	3,796	1,453	38.3	10.4	11.0	63.4	100
Virginia	15,451	8,332	53.9	6.7	6.8	92.7	88.9
West Virginia	54,631	26,660	48.8	8.3	9.0	80.1	56.5
Total	**121,499**	**56,973**	46.9	8.1	8.6	84.3	72.3

* Values are weighted means based on county populations.

Table 2.—Observed and Expected Deaths From Stomach Cancer Among White Men and Women in Coal Mining Areas of Seven States, 1950 to 1969*

Location of Coal Mining Areas	Men			Women		
	No. of Observed Deaths	No. of Expected Deaths	Risk Ratio	No. of Observed Deaths	No. of Expected Deaths	Risk Ratio
Illinois	20	15.0	1.3	13	6.3	2.1†
Kentucky	277	249.4	1.1	159	157.6	1.0
Ohio	28	24.0	1.2	16	12.2	1.3
Pennsylvania	83	43.3	1.9‡	47	30.6	1.5§
Utah	45	37.6	1.2	17	15.6	1.1
Virginia	115	60.6	1.9‡	58	52.2	1.1
West Virginia	401	291.7	1.4‡	203	172.4	1.2
Total	**969**	**721.6**	1.3‡	**513**	**446.9**	1.2§

* Number of expected deaths based on rates in control counties. Risk ratio = observed deaths/expected deaths.
† $P < .05$.
‡ $P < .001$.
§ $P < .01$.

Table 3.—Observed and Expected Deaths From Selected Neoplasms Among White Men and Women in Coal Mining Areas of Seven States, 1950 to 1969*

Type of Neoplasm	List No.[14]	Men			Women		
		No. of Observed Deaths	No. of Expected Deaths	Risk Ratio	No. of Observed Deaths	No. of Expected Deaths	Risk Ratio
Colon	153	591	699.7	0.8†	681	835.3	0.8†
Lung	164-165	2,223	1,698.3	1.3†	403	355.2	1.1‡
Breast	170	...	...	...	1,022	1,159.6	0.9†
Cervix	171	...	...	...	766	654.2	1.2†
Leukemia	204	518	572.7	0.9‡	369	346.8	1.1

* States studied were Illinois, Kentucky, Ohio, Pennsylvania, Utah, Virginia, West Virginia. Number of expected deaths based on rates in control counties. Risk ratio = observed deaths/expected deaths.
† $P < .001$.
‡ $P < .05$.

When there was no exact match by educational status, a control county with the next highest educational level was chosen. For three states with one coal mining county, two additional control counties were selected to provide a more stable estimate of risk. Expected deaths from gastric cancer were calculated by multiplying age- and sex-specific death rates in control counties by populations in coal mining counties over the time period. These values were compared with the observed number of deaths, assuming a Poisson distribution,[12] by means of risk ratios (observed/expected).

Similar analyses were made for other neoplasms; three associated with higher social class (leukemia, breast, and colon cancers) and two associated with lower socioeconomic status (lung and cervical cancers).[13]

Results

Overall, a close match was achieved for median school years completed (Table 1). The two groups of counties differed by only six months of schooling. Matching on this variable also produced a close match by an economic status indicator. The median family income was $3,642 for the coal mining counties and $4,000 for the control group. The counties were also similar with respect to urbanization and the percentage of the foreign-born in the population. In both groups, over 70% of the population lived in rural areas and less than 1% were foreign-born.

Stomach cancer mortality in seven coal mining areas is shown in Table 2. Among men, there were 969 deaths from the neoplasm compared with 721.6 deaths expected from rates in control counties ($P<.001$). Among women, 513 deaths were observed compared with 446.9 cases anticipated from mortality in the control group ($P<.01$). The excess mortality in coal mining counties was slightly greater for men than women in all states except Illinois and Ohio. There were 11 deaths attributed to stomach cancer in the two Utah counties (Carbon and Emery) during 1965 to 1969, the years covered by previous studies,[1,2] as compared with six expected ($P<.05$).

Among men in coal mining areas, deaths were excessive from lung cancer ($P<.001$) but were significantly low from leukemia ($P<.05$) and colon cancer ($P<.001$). Women had increased deaths from neoplasms of the cervix ($P<.001$) and lung ($P<.05$), while mortality from breast and colon cancers was less than expected ($P<.001$) (Table 3).

Comment

Mortality from stomach cancer is excessive among persons from the lower socioeconomic classes.[9] Our study showed a significantly high risk of gastric cancer among residents of coal mining counties compared with residents of non-coal mining regions who had similar education and income. However, a comparable increase in mortality was observed for cancers of the lung and cervix, while fewer than expected deaths occurred as a result of leukemia and breast and colon cancers. These observations are consistent with the anticipated distribution of malignancy based on a social class gradient. The approximately equal increased risk of stomach cancer in both sexes in coal mining areas is additional evidence that the increased deaths reflect some component of socioeconomic class rather than exposure to coal-related carcinogens.

Counties were matched by a variable which we thought was a good measure of social class (median years of education). This match also produced a comparison group which resembled the coal mining counties with respect to median family income. However, the data are convincing that this method did not produce a satisfactory match for social class. With further use of our newly developed resource, 20 years of cancer mortality on a county level, we will experiment with additional measures and combinations of measures available for counties in an effort to identify a better indicator of socioeconomic status.

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